BIBLIOGRAPHY

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ABSTRACT

The aboveground biomass yield of saplings of four different agroforestry species were obtained at the Benguet State University –Institute of Highland Farming Systems and Agroforestry, Bektey, Puguis, La Trinidad, Benguet from September 2002 to February 2003.

Calliandra (*Calliandra calothyrsus* Meissn.), Ipil-ipil [*Leucaena leucocephala (Lam.*) de Wit (MIM)], Alnus [*Alnus maritima (*Marsh.) Muhl. ex Nutt.] and Flemingia [*Flemingia macrophylla (Willd.*) Merr.] were evaluated for growth characteristics and their nitrogen, phosphorous and potassium contents in tissue samples. Likewise, their influences on the soil pH, soil organic matter, nitrogen, phosphorus and potassium contents were also gathered.

Results revealed that Calliandra exhibited better performance over the other agroforestry woody species used in the study. It grew faster, produced the biggest and longest lateral shoots and yielded the highest fresh weight, oven dry weight and total aboveground plant biomass than all the other species although it produced the least number of laterals. On the other hand, *Flemingia* did not significantly differ with

Calliandra in terms of the number of laterals, average base diameter of laterals, fresh weight, oven dry weight and aboveground plant biomass yield.

Meanwhile, Ipil-ipil produced the most number, albeit thinnest and shortest laterals but yielded the least fresh weight, oven dry weight and aboveground plant biomass. Finally, *Alnus* performed comparably to Ipil-ipil in terms of the number, length and base diameter of laterals, fresh weight, oven dry weight and aboveground plant biomass yield.

Plant tissue analysis showed that *Alnus* yielded significantly higher nitrogen, phosphorus and potassium content while *Calliandra* had the lowest nitrogen and potassium content at five months after clipping. On the other hand, *Flemingia* tissues yielded the lowest phosphorous.

Most of the Agroforestry species studied caused increase in soil acidity (decrease in pH) except Calliandra, resulting to significant differences in final soil pH. Soil nitrogen decreased in all species, most especially in Ipil-ipil. Soil phosphorus content was significantly higher in Calliandra and Ipil-ipil but was lowest in Alnus. Meanwhile, soil potassium content decreased in all species used, with the greatest decrease observed in Flemingia. Finally, soil organic matter increased in Alnus but decreased in all other species.

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INTRODUCTION

Our planet's life is nature's storehouse of solar energy and chemical resources. Whether cultivated by man or growing wild, plant matter represents a massive quantity of a renewable resource that we call biomass. The term biomass refers to all the earth's vegetation and many products and co-products that come from it. Biomass is the oldest known source of renewable energy – humans have been using it since we discovered life – and it has high energy content. Biomass contains energy that has been stored through photosynthesis. Energy derived from biomass does not have the negative environmental impact associated with non-renewable energy sources (Anonymous, 2001).

According to the International Center for Research and Agroforestry (ICRAFT) (1997), biomass is defined in Agroforestry as the quantity of biological matter present in a unit area; maybe total or often only above ground. It further stated that biomass may be separated into plant and animal mass or further divided into mass of standing crop or the portion of a stand and then unto foliage, branch, stem, flowers and so on.

Consequently, though is being given to extending the use of biomass so that every part of the harvestable portions of the plant can be utilized. The underlying assumption is that high biomass yields will make a greater contribution towards securing our energy supplies and t his will result in a larger amount of value added (Kleinhanss, 1991).

Biomass for energy use, according to the time and method of harvest and economy, includes roots, tubers, stems or branches, leaves, fruits and seeds or even whole plants. Those parts are used preferentially, however, which have a high energy density, in order to achieve high yields (El Bassam, 1995).

Agroforestry is defined by AICRAFT (1997) as a land-use system which involves integration of crops, agricultural crops and/ or animals, socially and economically, in same unit of land either in sequential or spatial arrangement. It further stated that certain crop combinations may produce differently in terms of yield, growth performance, etc. in different locations. This may be because of different factors present in certain area. It also emphasized that biomass production of certain crop also varies because it is affected by location, kind of crop and other environmental factors.

Results of the study will serve as baseline data on aboveground biomass production for selected Agroforestry woody species used as hedgerows for future reference. It may also serve as a guide in designing Agroforestry farms, particularly in terms of farm productivity, either economically or ecologically. Furthermore, results of the study can impart information to guide farmers to take into consideration proper integration of crops in designing their Agroforestry farming system and enhancement of their indigenous knowledge.

In general, the objective of the study was to evaluate the aboveground biomass production of selected Agroforestry woody hedgerow species under La Trinidad, Benguet condition. Specifically, the study aimed to 1) establish baseline date on the quantity of aboveground biomass production of different Agroforestry woody hedgerow species; 2) compare the growth rate and quantity of aboveground biomass production of different Agroforestry woody hedgerow species under La Trinidad, Benguet condition; and 3) determine the effect of the different Agroforestry woody hedgerow species on NPK content, OM, and pH of soil.

The study was conducted at the Benguet State University Institute of Highland Farming Systems and Agroforestry, Bektey, Puguis, La Trinidad, Benguet from September 2002 to February 2003.

REVIEW OF LITERATURE

Renewable energy sources offer the possibility to ensure energy supply in the future. Biomass, among all renewable energy sources, has the highest potential for substitution of fossil fuel in various regions of the world. Advanced technology in bioenergy would facilitate decentralized rural electrification and thereby promote rural development (El Bassam, 1999).

Eculin studies of El Bassam (1995) found that energy plants are understood to mean those annual and perennial varieties which can be cultivated to produce solid or liquid energy sources.

Wood-fed power plants are as old as electricity. Wood used to be an important energy source for the generation of electricity and eventually became a relatively scarce and expensive fuel so its use declined. Today, energy economics found wood to be attractive again (Denton, 1984).

For every hectare of land, the Philippines receives about 2 million kWh of energy per year from the sun. The total electrical energy generated in the Philippines during 1980 was about 18,000 kWh. Consequently, the sunlight falling on about 1,000 ha of land each year is equivalent to the total electricity generation of the nation. The sun's falling on only 3,000 – 4,000 ha of land is equivalent to our total commercial energy consumption in 1980. That is, there is an enormous potential source of indigenous power from sunlight (Denton, 1984).

Many plants contain hydrocarbons that are similar in composition to petroleum products. These occur in crude form in leaves, trunks, bark, seeds and sap of plants. In the Philippines, 44 potential energy plants have been identified by the National Science and Technology Authority in 1982 that show promise as fuel sources and deemed fit for mass cultivation, both in lowlands and uplands (Quinones and Bravo, 1996).

Farms with trees have higher levels of available micronutrients such as nitrogen, potassium and calcium but with lower levels of phosphorous than farms without trees. Available amounts of micronutrients such as boron, molybdenum, and manganese are higher on farms with trees (Cadelina, 1987).

The pH of the soil is another factor that affects the growth of plants. It is important because it affects the solubility of plant food and microbial activities in the soil (Sangatanan *et al.*, 1995).

The pH of the soil correlated significantly with the Ca content of the lead litter. The content of organic matter and exchangeable cations differed significantly between the various trees species and compared with the control using grass vegetation (El Bassam, 1999).

According to the World Health Organization as cited by Quinones and Bravo (1996), in the long run, the soaring demand for the fuel made it more expensive. The increase in its use aggravated pollution problems since exhaust from diesel-run engines were denser compared to gasoline in terms of sulfur dioxide, nitrogen oxides, carbon monoxide, and total suspended particulates.

Forest biomass refers to all aboveground plant materials. It can include small or dead trees, shrubs and the tops, foliage or limbs or large commercial valuable trees. Because these materials are typically left on the forest floor to decompose, biomass harvesting represents a broadening of forest materials that can be used. Operationally, biomass harvesting is equivalent to whole-tree (Nakamura, 1996).

MATERIALS AND METHODS

The study was conducted at the BSU-Institute of Highland Farming Systems and Agroforestry, Bektey, Puguis, La Trinidad, Benguet. The area measured approximately 150 m^2 and with existing terraces planted to Arabica coffee trees. Guava and banana, including some indigenous plant species were also present in the immediate surroundings of the study area. The specimens were planted as hedgerows along the terrace edges. The area has an average slope of 32º or 71%, facing east with an elevation of approximately 1,380 meters above sea level. Figure 1, 2 and 3 show the study area before clearing, after clearing, and before planting, respectively.

Saplings of four different agroforestry hedgerow species namely; Calliandra (*Calliandra calothyrsus* Meissn.), Ipil-ipil [*Leucaena leucocephala (Lam.*) de Wit (MIM)], Alnus [*Alnus maritima (*Marsh.) Muhl. ex Nutt.] and Flemingia [*Flemingia macrophylla (Willd.*) Merr.], were used in the study. The seedlings were procured from the Benguet State University College of Forestry nursery, while those not available were obtained from the Department of Environment and Natural Resources (DENR-CAR) nursery, Pacdal, Baguio City.

Four of the species namely: *Calliandra calothyrsus, Leucaena leucocephala* (Ipil-ipil), and *Flemingia macrophylla* were seven months old while *Alnus maritima* was 11 months old at the time of planting.

Initially, saplings of Sesbania [*Sesbania sesban(L.*) Pers.] were included in the study but were excluded later due to very high mortality.

Figure 1. Experiment area before clearing

Figure 2. Experiment area after clearing and before planting

Figure 3. Experiment area with hills/holes ready for planting

The saplings were planted as hedgerows at dense planting (20 cm distance) arranged in a Randomized Complete Block (RCB) Design, replicated three times. The treatments were as follows:

T_1 - Calliandra (*Calliandra calothyrsus* Meissn.)

T_2 - Ipil-ipil [*Leucaena leucocephala (Lam.*) de Wit (MIM)],

T_3 - Alnus [*Alnus maritima (*Marsh.) Muhl. ex Nutt.]

T_4 - Flemingia [*Flemingia macrophylla (Willd.*) Merr.]

The hedgerows were clipped (the stem was cut) at 20 cm aboveground one month after planting. Figure 4, 5 and 6 show the plants before and after clipping, respectively. A one cubic meter ($1m^{3)}$ bottomless box frame was positioned at level with the cut to accommodate growth after cutting. Growth data were gathered on a monthly basis for five months.

Figure 4. Plants (indicated by arrows) before clipping at 20 cm above soil level

Figure 5. Fresh plant samples ready for biomass analysis

Figure 6. Soil samples taken after the study for laboratory analysis

Data Gathered:

A. Growth

1. Number of lateral shoots produced. Five sample plants were taken per species per replication and the number of shoots produced was counted.

2. Growth rate (cm). This was measured every month from the base of five sample shoots taken at random per species per replication.

3. Average base diameter of laterals (cm). This was measured using a vernier caliper at the end of the study from five sample shoots taken at random per species per replication.

4. Fresh weight (g). The growth accommodated in the box was cut, gathered and weighed using beam balance. It was taken from five sample plants per species. This was gathered at the end of the study.

5. Oven dry weight (g). After taking the fresh weight, the plant parts gathered were oven-dried and subsequently weighed. It was done per sample per species. Biomass was computed as follows:

$$\text{Biomass} = \frac{\text{Fresh Weight (FW)} - \text{Oven Dry Weight (ODW)}}{\text{Fresh Weight (FW)}} \times 100$$

6. NPK content. Separate tissue analysis was done for NPK content. This was obtained from plant parts gathered at the end of the study.

B. Soil Analysis

Soil analysis was done at the Soil Science Laboratory, Department of Soil Science, College of Agriculture.

1. Soil pH. The soil pH where the respective species were planted was obtained through analysis of soil samples taken before and after the study.

2. Organic matter content. This was obtained through analysis from soil samples obtained from the respective area where each of the species was planted taken before and after the study.

3. NPK content. It was obtained through analysis and a quantitative test. The tests were done on soil samples taken before and after the study.

C. Local Meteorological Data

Local meteorological data was obtained at the BSU PAG-ASA station in Balili, La Trinidad, Benguet.

1. Average monthly temperature. The average monthly temperature of La Trinidad, Benguet was obtained. The data covered only the study period.

2. Average monthly rainfall. The average monthly rainfall of La Trinidad, Benguet was obtained. The data covered only the study period.

3. Relative humidity. Relative humidity data in La Trinidad covering the duration of the study was obtained

4. Sunshine hours. Sunshine hours were obtained directly from the area by recording the exact time when the sunshine struck the area up to the time sunlight disappeared or when the area was no longer exposed to sunlight.

RESULTS AND DISCUSSION

Growth Parameters

Average Shoot Length

Average shoot length measured after six months is shown in Table 1. Almost all of the plants recorded high growth increments during third and fourth month (November and December, respectively) after planting as shown in Figure 7. Growth drastically slowed towards dry season as the amount of available water decreased. Statistical analysis showed significant differences among the treatments especially on Calliandra. The other woody perennials used did not significantly differ from each other. Calliandra produced the longest shoots (108.2 cm), followed by Flemingia (98.6 cm) and Alnus (53.6 cm) while *Leucaena* (ipil-ipil) had the lowest shoot length with 43.5 cm., except *Sesbania* where most of the test plants died on the second to third months after clipping.

Figure 7 shows the comparative monthly shoot growth of the hedgerow species for five months. Calliandra and Flemingia exhibited almost similar growth curves while ipil-ipil (*Leucaena*) had an almost flat growth rate. Growth of all species declined in the fifth month.

Table 1. Average shoot length at six months

TREATMENT	LENGTH (cm)
Calliandra	108.2 [b]
Ipil-ipil	43.5 [a]
Alnus	53.6 [a]
Flemingia	98.6 [a]

*Means with a common letter are not significantly different at 5% DMRT.

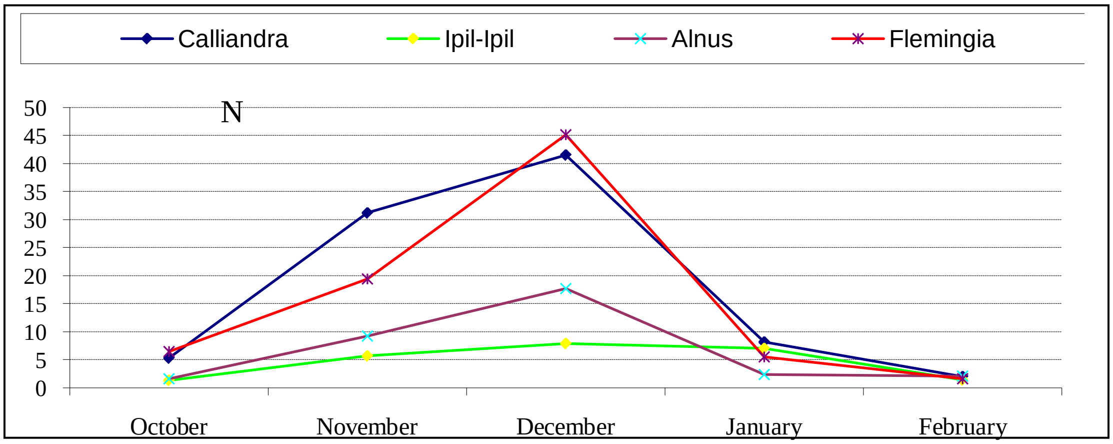

Figure 7. Average shoot growth (cm) per month of the different hedgerow species

Number of Lateral Shoots Produced

Table 2 shows the average number of lateral shoots produced five months after clipping. Statistical analysis revealed highly significant differences among the treatments. Ipil-ipil (*Leucaena*) produced the most number of laterals (23.0) while Alnus and Flemingia produced 21.7 and 12.7 laterals, respectively. On the other hand, Calliandra produced the fewest laterals with 11.7.

Table 2. Number of lateral shoots produced after clipping

TREATMENT	AVE. NO. OF LATERALS
Calliandra	11.7 [c]
Ipil-ipil	23.0 [a]
Alnus	21.7 [b]
Flemingia	12.7 [c]

*Means with a common letter are not significantly different at 5% DMRT.

Average Base Diameter

The average base diameter of laterals from the five different agroforestry tree species is shown in Table 3. Statistical analysis showed no significant differences among the treatments. However, Calliandra and Flemingia produced laterals with biggest average base diameters of 1.5 cm and 1.11 cm, respectively. Laterals of ipil-ipil had 0.73cm while Alnus had 0.63cm average diameter at the base.

Fresh Weight

Table 4 shows the fresh weight of plants in grams. Significant differences among treatments were revealed by statistical analysis. Calliandra accumulated the greatest biomass with a mean of 249.80g, followed by Flemingia with 219.99 g, then by Alnus with 46.13 grams. On the other hand, ipil-ipil produced only 34.70 g of fresh matter. The growth of Alnus and Ipil-ipil was observed to be slow and not vigorous in the study site

Table 3. Average base diameter of laterals

TREATMENT	DIAMETER (cm)
Calliandra	1.50
Ipil-ipil	0.73
Alnus	0.63
Flemingia	1.11

*Means with a common letter are not significantly different at 5% DMRT.

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Table 4. Fresh weight of plants

TREATMENT	WEIGHT (g)
Calliandra	249.90 [a]
Ipil-ipil	34.70 [c]
Alnus	46.13 [bc]
Flemingia	219.93 [ab]

*Means with a common letter are not significantly different at 5% DMRT.

<u>Oven Dry Weight (g)</u>

Oven dry weight (ODW) of plant sample is shown in Table 5. Statistical analysis showed significant differences among treatments. Calliandra recorded the highest ODW of 108.679 g, followed by Flemingia with 100.67g, then by Alnus with 23.13g. Ipil-ipil had the lowest ODW with 20.33 g.

Table 5. Oven-dry weight of plants

TREATMENT	WEIGHT (g)
Calliandra	108.67 [a]
Ipil-ipil	20.33 [c]
Alnus	23.13 [c]
Flemingia	100.67 [ab]

*Means with a common letter are not significantly different at 5% DMRT.

Aboveground Biomass Yield

The computed aboveground biomass yield in grams of the different agroforestry species is shown in Table 6. Statistical analysis revealed significant differences among treatments. Calliandra yielded the most biomass with 56.5g, followed by Flemingia with 54.47g, then by Alnus with 49.97grams. Ipil-ipil yielded the least biomass with 43.0g.

Figure 8 shows the relationship between the fresh weight (FW), oven dry weight (ODW) and computed biomass. Calliandra and Flemingia had very high fresh weight, but that a large part of it was water that was removed by oven drying. Nevertheless, their computed biomass yields were still higher than either Alnus or Ipil-ipil.

Table 6. Aboveground biomass

TREATMENT	WEIGHT (g)
Calliandra	56.50 [a]
Ipil-ipil	43.00 [b]
Alnus	49.97 [ab]
Flemingia	54.47 [a]

*Means with a common letter are not significantly different at 5% DMRT.

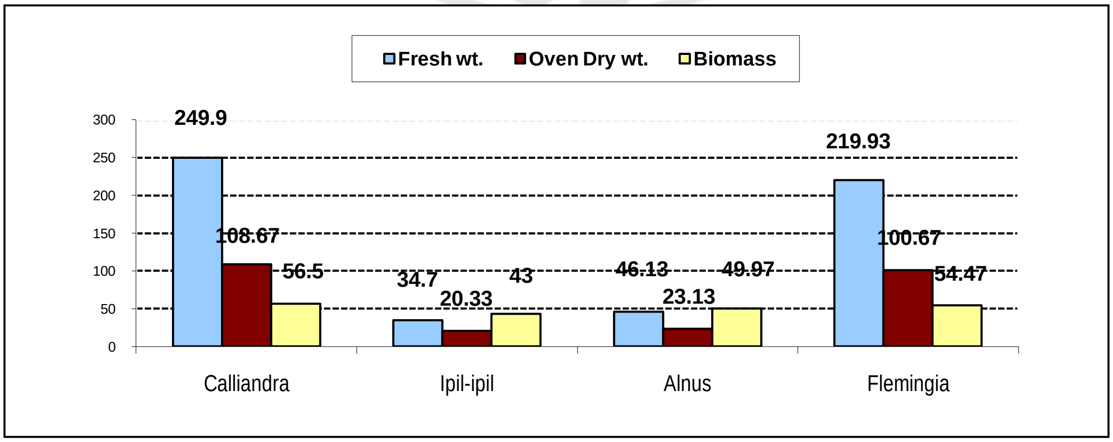

Figure 8. Comparative fresh weight, oven dry weight and biomass of plants (g)

Table 7. Nitrogen content of the plants

TREATMENT	N (%)
Calliandra	3.05 [a]
Ipil-ipil	3.30 [a]
Alnus	19.30 [b]
Flemingia	3.60 [ab]

*Means with a common letter are not significantly different at 5% DMRT.

Nitrogen Content of Plants

Table 7 presents the nitrogen content of tissue samples from the four agroforestry species studied. Statistical analysis revealed highly significant differences in the nitrogen content of the plants. Alnus had the highest nitrogen content of 4.40%, followed by Flemingia (3.60%) and Ipil-ipil (3.30%). Calliandra had the lowest nitrogen content of 3.03%, comparable to ipil-ipil and Flemingia.

Phosphorus Content of the Plants

Table 8 shows the phosphorus content of plant. There were highly significant differences among the treatments. It was found out that Alnus had the highest phosphorus content of 19.3 ppm. On the other hand, Flemingia yielded the lowest phosphorous content of 13.3 ppm. Calliandra and Ipil-ipil yielded statistically similar phosphorus contents of 15.9 ppm and 15.6 ppm, respectively.

Table 8. Phosphorous content of the plants

TREATMENT	P (ppm)
Calliandra	15.9 [b]
Ipil-ipil	15.6 [b]
Alnus	19.3 [a]
Flemingia	13.3 [c]

*Means with a common letter are not significantly different at 5% DMRT.

Potassium Content of Plants

Potassium content of plants is shown in Table 9. There were significant differences observed among the treatments. Alnus had the highest potassium content of 24.8%. On the other hand, Calliandra had the lowest potassium content of 11.9%. Meanwhile, Ipil-ipil and Flemingia

A summary of the nitrogen, phosphorus and potassium contents of the agroforestry tree species after five months is shown in Figure 9.

Table 9. Potassium content of the plants

TREATMENT	K (%)
Calliandra	11.9 [c]
Ipil-ipil	16.8 [b]
Alnus	24.8 [a]
Flemingia	13.9 [bc]

*Means with a common letter are not significantly different at 5% DMRT.

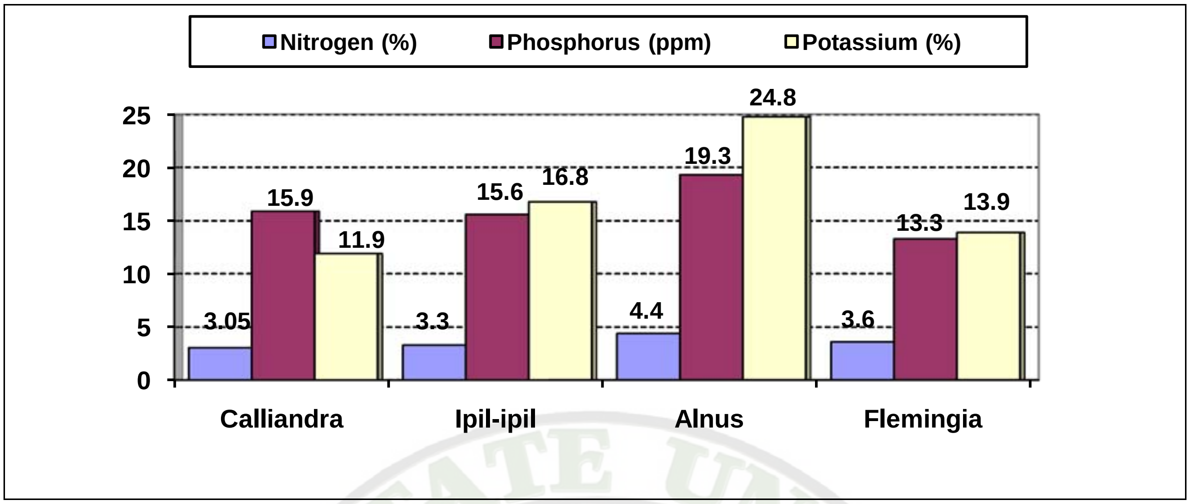

Figure 9. N, P, and K content of the four Agroforestry species.

Figure 9 shows the nitrogen, phosphorus and potassium contents of plant tissue samples taken from the test plants. Alnus yielded the highest nitrogen, phosphorus and potassium among the treatment plants with 4.4 %, 13.3 ppm and 13.9%, respectively. On the other hand, Calliandra yielded the lowest nitrogen and potassium contents of 3.05% and 11.9%, respectively. Flemingia recorded the lowest phosphorus content of 13.3 ppm.

Soil Analysis

Soil pH Before and After the Study

The pH of soil before and after the study is shown in table 10 and Figure 4. The pH of the soil was observed to range from strongly acidic to medium acidic before the study with slight changes after the study. Nevertheless, Calliandra significantly differed from that of alnus by increasing soil pH from 4.79 (very strong acid) to 5.90 (medium strong acid). On the other hand, Ipil-ipil increased soil acidity from 4.96 to 4.75 while Flemingia reduced soil acidity from 4.77 to 4.94

Table 10. Soil pH

TREATMENT	pH OF SOIL	
	BEFORE	AFTER
Calliandra	4.79 (very strong acid)	5.90[a] (medium strong acid)
Ipil-ipil	4.96 (very strong acid)	4.75 [ab] (very strong acid)
Alnus	4.72 (very strong acid)	4.64 [b] (very strong acid)
Flemingia	4.77 (very strong acid)	4.94 [ab] (very strong acid)

*Means with a common letter are not significantly different at 5% DMRT.

According to Ranst Van as cited by Faroden (1997), the amount of acidity which maybe present in tropical soils strongly depends on the stage of evolution and subsequent mineralogy. The processes necessary to develop acidity are: accumulation of organic matter, breakdown of primary minerals and leaching of soluble constituents.

Figure 10 shows the change in soil pH after the study. Calliandra and Flemingia caused increase in soil pH by values of 1.11 and 0.17, respectively. On the other hand, Ipil-ipil lowered the soil pH by -0.21, followed by Alnus (-0.08).

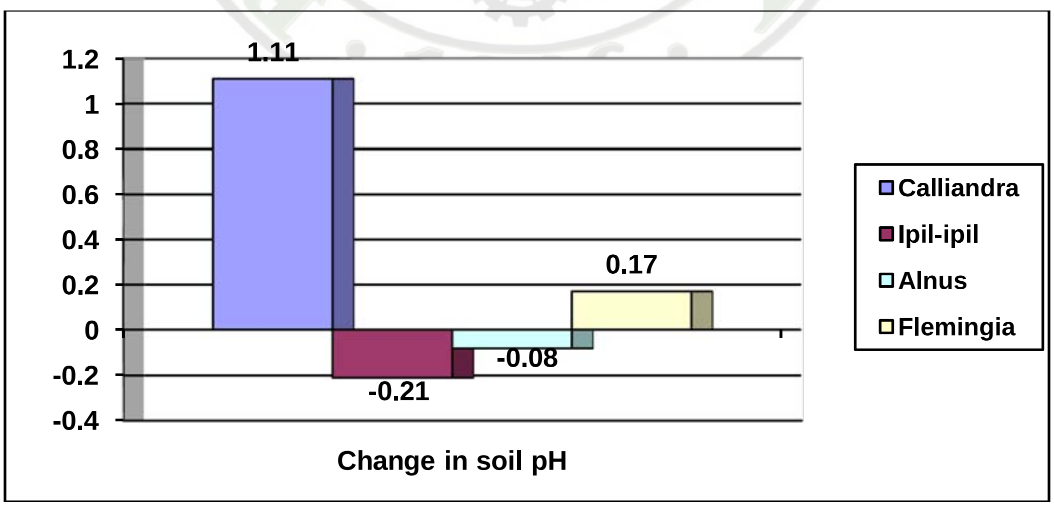

Figure 10. Change in soil pH after the study

Organic Matter Content of the Soil

Before and After the Study

Organic matter content of soil before and after the study is presented in Table 11. Results show that there were significant differences among treatments with respect to the OM content before the study. Organic matter content of soil before planting was highest in the area planted to ipil-ipil (2.02 ppm) and lowest in Flemingia (1.35 ppm).

OM content after the study showed that the area planted to Alnus had the highest OM content (2.03 ppm) while that of ipil-ipil had the least OM content (0.76 ppm). Areas planted to Flemingia and Calliandra recorded 1.10 and 0.90 ppm OM content after the study, respectively. Statistical analysis revealed highly significant differences among the treatments in the final OM content of the soil.

Changes in the Organic matter content of soil after the study are reflected in Figure 11. This would indicate that the growing saplings affected the OM content of soil. Soil planted with Ipil-ipil, Calliandra and Flemingia showed decrease in organic matter content by negative values of 1.26, 1.03 and 0.25 ppm, respectively. On the other hand, soil planted with Alnus showed an increase in OM content by 0.25 ppm.

Table 11. Organic matter content of soil before and after the study

TREATMENT	BEFORE (ppm)	AFTER (ppm)
Calliandra	1.93 [a]	0.90[b]
Ipil-ipil	2.02 [a]	0.76[b]
Alnus	1.78 [a]	2.03[a]
Flemingia	1.35 [b]	1.10[b]

*Means with a common letter are not significantly different at 5% DMRT.

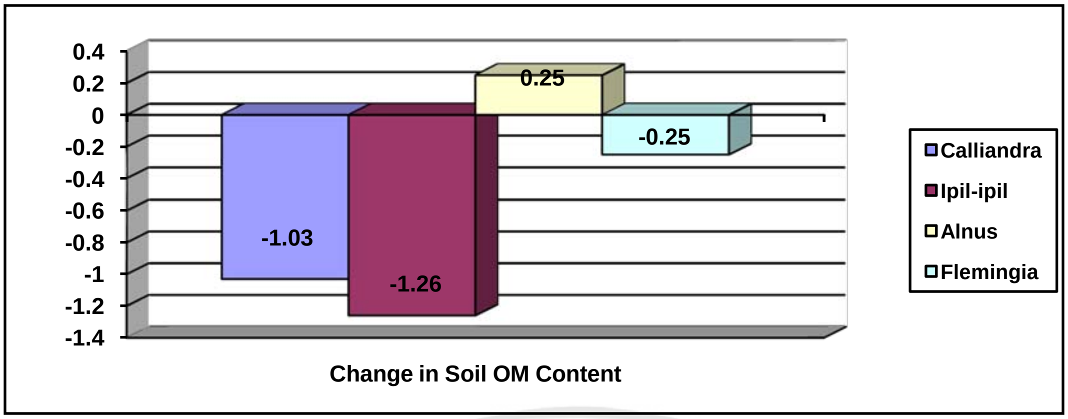

Figure 11. Changes in the organic matter content of soil (ppm)

Nitrogen Content of Soil Before and After the Study

Nitrogen content of soil before and after the study is shown in Table 12. Statistical analysis revealed significant differences among the treatments in the soil nitrogen content of the soil before the study. Soil N-content was highest in Calliandra and Ipil-ipil (both 0.10 ppm), but was lowest in Flemingia (0.07 ppm) before the study.

After the study, soil planted with Ipil-ipil turned out to contain the least Nitrogen with 0.040 ppm. On the other hand, Calliandra and Flemingia recorded soil N contents of 0.047 and 0.057 ppm, respectively. Alnus had the highest soil N content of 0.070 ppm. However, statistical analysis revealed no significant differences in the soil N content of the treatments.

Results show the depletion of soil Nitrogen at the early growth stage of trees. According to McCollum (1985) as cited by Codiamat (1996), nitrogen builds up the vegetative growth of the plants producing large green leaves and also it is necessary for filling out. Nitrogen in soil naturally depleted at early stage of growth for production of leaves and other parts.

Table 12. Nitrogen content of soil

TREATMENT	BEFORE (ppm)	AFTER (ppm)
Calliandra	0.10 [a]	0.047
Ipil-ipil	0.10 [a]	0.040
Alnus	0.09 [a]	0.070
Flemingia	0.07 [b]	0.057

*Means with a common letter are not significantly different at 5% DMRT.

Figure 12 shows the changes in nitrogen content of the soil after the study indicating that indeed, the plants absorbed and used nitrogen from the soil for their growth. Ipil-ipil and Calliandra caused the decrease in soil N by 0.06 and 0.053 ppm, respectively. This means that they used up the most N. On the other hand, Alnus and Flemingia reduced soil N by only 0.01 and 0.013 ppm, respectively.

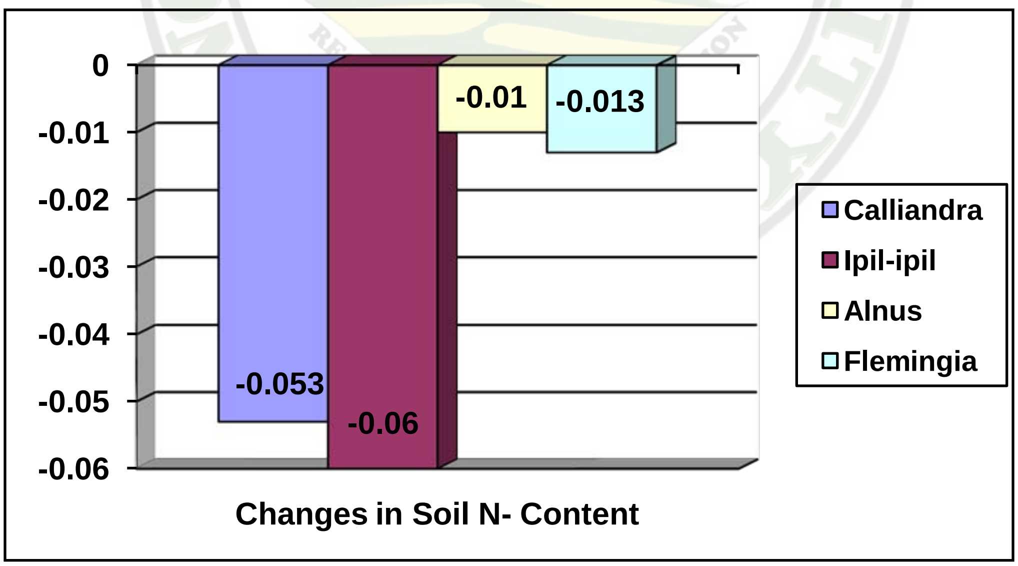

Figure 12. Reduction in Nitrogen content of soil (ppm)

Phosphorus Content of Soil
Before and After the Study

Phosphorus content of soil before and after the study is presented in Table 13. There were no significant differences among the treatment before the study. However, after the study, highly significant differences were observed among the treatments with respect to the soil phosphorus content. Soil with Alnus recorded the lowest phosphorus content of 6.72 ppm, followed by Flemingia with 13.66 ppm. On the other hand, soil with Calliandra and Ipil-ipil recorded the highest phosphorus content of 26.55 and 20.17 ppm, respectively.

Figure 13 shows the changes in the soil phosphorus content after the study. Alnus caused a decrease in the phosphorus content of the soil by 2.59 ppm. On the other hand, Flemingia, Ipil-ipil and Calliandra caused increase in soil phosphorus content by 5.73, 8.79 and 17.93, respectively.

Table 13. Phosphorus content of soil

TREATMENT	BEFORE (ppm)	AFTER (ppm)
Calliandra	8.62[a]	26.55 [a]
Ipil-ipil	11.38 [a]	20.17 [ab]
Alnus	9.31 [a]	6.72 [c]
Flemingia	7.93 [a]	13.66 [b]

*Means with a common letter are not significantly different at 5% DMRT.

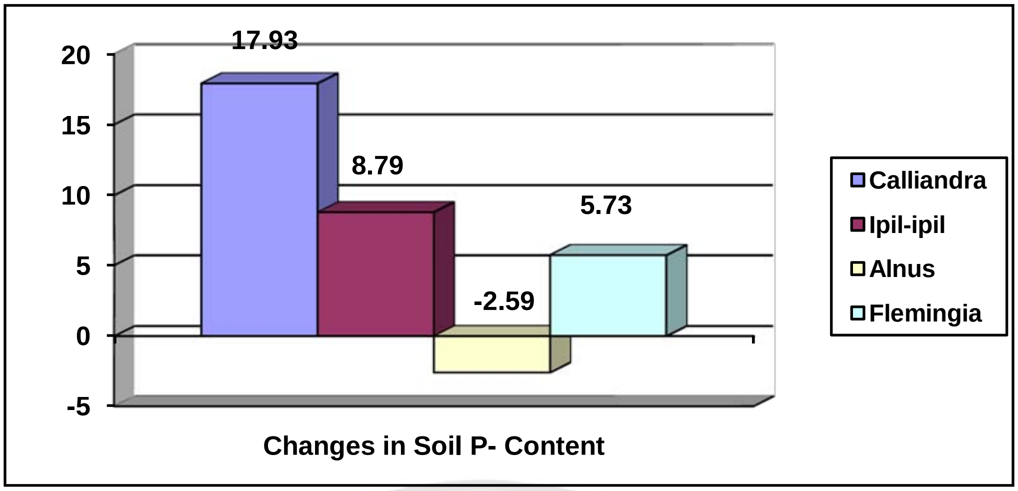

Figure 13. Changes in soil Phosphorus content (ppm)

Potassium Content of the Soil
Before and After the Study

Table 14 shows the potassium content of the soil before and after the study. All of the species caused a decrease in potassium content of soil after the study. Significant differences were obtained among the treatments in terms of potassium content of soil after the study. Soil planted with Alnus recorded the highest final potassium content of 3.0 ppm, followed by Ipil-ipil with 2.5 ppm, and Calliandra with 1.8 ppm. Soil planted with Flemingia recorded the lowest potassium content with 1.7 ppm.

Table 14. Potassium content of soil

TREATMENT	BEFORE (ppm)	AFTER (ppm)
Calliandra	2.9	1.8 [b]
Ipil-ipil	2.8	2.5 [ab]
Alnus	3.3	3.0 [a]
Flemingia	3.3	1.67 [c]

*Means with a common letter are not significantly different at 5% DMRT.

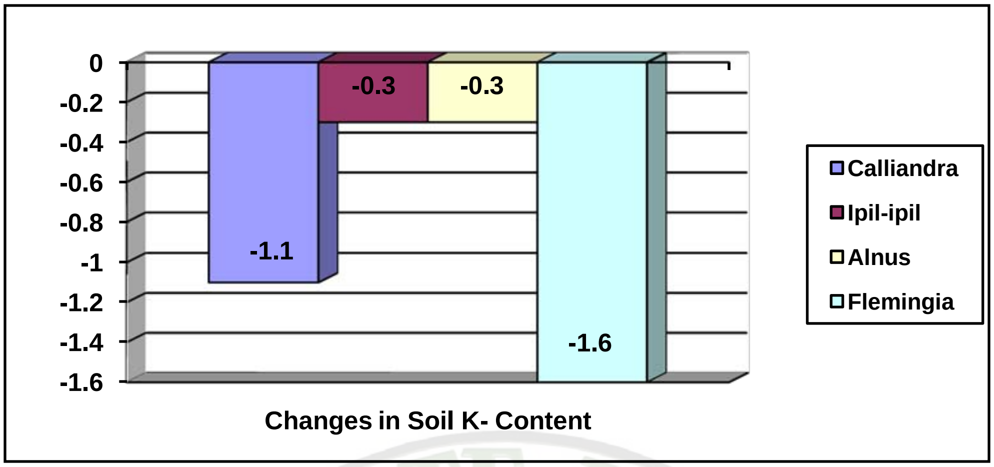

Figure 14. Changes in Potassium content of soil (ppm)

According to Balantan (2002) the K-uptake was correlated with the plant height and harvesting stage, corroborating the findings of this study (see Table 6). Figure 8 shows the changes in the soil potassium content before and after the study, indicating that potassium was absorbed by the plants at varying amounts.

In figure 14, it can be seen that Flemingia caused greatest depletion of potassium in the soil by 1.6 ppm, (from 3.3 to 1.7 ppm) followed by Calliandra, which caused 1.1 ppm reduction in potassium content of the soil (from 2.9 to 1.8ppm). Finally, Ipil-ipil and Alnus caused only 0.3 ppm reduction in the soil potassium content, the lowest among the treatments.

<u>Climatic Conditions</u>

Mean monthly temperature, relative humidity, rainfall and total bright sunshine during the conduct of the study are shown in Table 15. Minimum temperature ranged from 11.2 to 16.4ºC while maximum temperature ranged from 23.1 to 25.6ºC. Maximum temperature was highest during the month of September and minimum temperature was lowest at the month of November.

Table 15. Temperature, relative humidity, rainfall and total bright sunshine

MONTH	TEMPERATURE		RELATIVE HUMIDITY	RAINFALL/ MONTH	TOTAL BRIGHT SUNSHINE
	Min (ºC)	Max (ºC)	(%)	(mm)	(hr)
September	15.9	25.6	93.1	7.50	4.98
October	15.9	24.3	91.7	0.57	5.73
November	14.8	23.1	87.5	2.38	5.58
December	14.4	24.5	90.3	0.00	6.81
January	11.2	23.5	88.8	0.00	5.62
February	12.6	24.0	88.3	0.89	6.91

Relative humidity ranged from 87.5 to 93.1%. Highest rainfall was observed during the month of November. The longest duration of sunshine was recorded during the month of February and the shortest duration of sunshine was observed during the month of September.

The high mortality of Sesbania maybe due to the unfavorable climatic conditions such as low rainfall during the study period, which did not satisfy the rainfall/water requirement of above 1000 mm as cited in sesbania sesban tree (2001). Another probable reason is that the conditions in the study area are closer to subtropical/semi-temperate climate.

SUMMARY, CONCLUSION AND RECOMMENDATION

Different Agroforestry species were studied for aboveground biomass yield and their effects on the soil pH, OM, nitrogen, phosphorus and potassium contents of soil under La Trinidad condition. The study was conducted at the Benguet State University – Institute of Highland Farming Systems and Agroforestry (BSU-IHFSA), Bektey, Puguis, La Trinidad, Benguet from September 2002 to February 2003.

Of the species used in the study, *Calliandra calothyrsus* Meissn., *Flemingia macrophylla* (Willd.) Merr., *Alnus maritime* (Marsh.) Muhl.ex Nutt. and *Leucaena leucocephala* (Lam.) de Wit (MIM.) showed accelerated growth rate (Figure 1) during the third to fourth months after planting. On the other hand, most of the *Sesbania sesban* plants died around three months after planting or two to three months after clipping and were subsequently excluded from the study results.

Calliandra produced the longest shoots (108.2 cm) but the least number of laterals (11.7). In contrast, Ipil-ipil produced the most number of laterals (23), significantly more than all the other species studied, but was the shortest (43.5 cm) and had smaller average base diameter of laterals than either Calliandra or Flemingia. Alnus had the smallest average base diameter of laterals (0.63 cm) but performed similarly with Ipil-ipil in terms of number, shoot length, fresh and oven dry weight and aboveground biomass yield. Flemingia and Calliandra produced the least number of laterals.

Calliandra had the highest fresh weight (0.63 g), oven dry weight (108.67 g) and aboveground biomass yield (56.5g). Significant differences were observed in aboveground biomass, which was highest in Calliandra (56.5 g) and lowest in Ipil-ipil (43.0 g).

Plant tissue analysis showed that Alnus yielded significantly higher phosphorus and potassium contents (19.3 ppm and 24.8%, respectively) but had comparable nitrogen content with Flemingia. Calliandra tissues yielded the lowest nitrogen and potassium contents (3.05 % and 13.3 %, respectively) at five months after clipping. Flemingia tissues yielded the lowest phosphorous (13.3 ppm).

In terms of their effect on the soil, Calliandra caused increase in the soil pH (+1.11), while all the other species caused a decrease in pH (increased soil acidity). There were significant differences in soil pH after the study. On the other hand, soil organic matter increased in Alnus (0.25 ppm) but decreased in all other species. Meanwhile, soil nitrogen decreased in all species but was greatly pronounced in Ipil-ipil (-0.06 ppm). In addition, soil phosphorus content decreased in Alnus but increased in the other species. After the study, soil phosphorus content was significantly higher in Calliandra and Ipil-ipil (+17.93 and 8.79 ppm, respectively) and lowest in Alnus (6.72 ppm). Soil potassium content decreased in all species resulting to significantly different final soil K content. The greatest decrease was observed in Flemingia (-1.6 ppm) while the least was observed in Alnus and Ipil-ipil (both –0.03 ppm).

The highest rainfall and lowest relative humidity was recorded during the month of November. The minimum temperature recorded this month was 14.8 ºC and the maximum is 23.1 ºC. Total bright sunshine averaged 335.0 min per day

It was observed that powdery mildew was prevalent in *Flemingia macrophylla* but did not affect the other test species. It was also observed that from three months after planting and onwards, Flemingia leaves showed mildew, which may be due to climatic factors such as the lack of sunlight and high moisture or humidity.

Clipping Sesbania 35 days after transplanting at 20 cm above the ground level is not recommended. However, irrigation is recommended for early growth establishment due to its shallow root system. Intensive care is further advised in growing Sesbania until it fully adapts to the area where it was transferred.

Sesbania is also frost sensitive, it is not wind resistant, and its brittle branches easily breaks. It is also observed to be susceptible to nematodes. It is best adapted to the moist tropics with annual rainfall in excess of 1,000 mm and no more than a few months dry season (Anonymous, 2001).

Finally, Calliandra and Flemingia are best for hedges/hedgerows because of high aboveground biomass production at five months old. These two crops are also fast growing, have big base diameter and better soil erosion prevention due to deep strong roots as visually observed.

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